THE EFFECTS OF PERSONALITY TYPE ON ENGINEERING STUDENT PERFORMANCE AND ATTITUDES*

R.M. Felder
Department of Chemical Engineering
North Carolina State University

G.N. Felder
Department of Physics
Stanford University

E.J. Dietz
Department of Statistics
North Carolina State University

Abstract

The Myers-Briggs Type Indicator® (MBTI) was administered to a group of 116 students taking the introductory chemical engineering course at North Carolina State University. That course and four subsequent chemical engineering courses were taught in a manner that emphasized active and cooperative learning and inductive presentation of course material. Type differences in various academic performance measures and attitudes were noted as the students progressed through the curriculum. The observations were generally consistent with the predictions of type theory, and the experimental instructional approach appeared to improve the performance of MBTI types (extraverts, sensors, and feelers) found in previous studies to be disadvantaged in the engineering curriculum. The conclusion is that the MBTI is a useful tool for helping engineering instructors and advisors to understand their students and to design instruction that can benefit students of all types.

I. INTRODUCTION

People have different learning styles that are reflected in different academic strengths, weaknesses, skills, and interests. Given the almost unlimited variety of job descriptions within engineering, it is safe to say that students with every possible learning style have the potential to succeed as engineers. They may not be equally likely to succeed in engineering school, however, since they respond differently to different instructional approaches and the predominant mode of instruction favors some learning styles over others.[1–3] Understanding learning style differences is thus an important step in designing balanced instruction that is effective for all students.

Probably the best-known instrument used to assess learning styles is the Myers-Briggs Type Indicator (MBTI).[4] Studies of type effects in engineering education have been carried out by a consortium of eight universities and the Center for Applications of Psychological Type[5,6] and by Rosati.[7-9] In all of these studies, introverts, intuitors, thinkers, and judgers generally outperformed their extraverted, sensing, feeling, and perceiving counterparts. (These terms will be explained shortly for readers who may not be familiar with the MBTI.) Rosati subdivided his population according to gender and general level of academic proficiency and noted that the strongest type differences in performance and retention were observed for academically weak male students..

An opportunity to augment the findings of these studies arose in the context of a longitudinal study carried out at North Carolina State University. One of the authors (RMF) taught five chemical engineering courses in five consecutive semesters to a cohort of students, beginning with the introductory chemical engineering course taught in the first semester of the sophomore year. The courses were taught using an instructional approach that differed in several ways from the one traditionally used in engineering education. The latter is essentially deductive, proceeding from theory to applications, while

* *Journal of Engineering Education, 91*(1), 3–17 (2002).

the experimental courses were taught more inductively, using applications and experimental results to motivate presentations of more abstract theoretical and mathematical material. The experimental courses also used a mixture of lectures and active learning experiences in class and a combination of individual and team-based (cooperative) assignments, as opposed to the usual approach, which is based almost exclusively on formal lecturing and individual assignments. An immense quantity of data was collected in the longitudinal study, much of which has been presented and discussed elsewhere.[10–14]

Early in the first experimental course, the students all completed Self-Scoring Form G of the Myers-Briggs Type Indicator.[15] Various measures of the students' academic performance, attitudes toward their instruction in both the experimental and non-experimental courses, and career goals and ambitions were correlated with their MBTI type preferences. Type differences in categorical variables were subjected to two-sided Fisher exact tests, and differences in numerical variables were subjected to Wilcoxon rank-sum tests.

One of the goals of the study was to test the degree to which the performance and attitudes of the students were consistent with expectations based on type theory and with the prior studies of type effects in engineering education. The extent of the agreement would provide an indication of the efficacy of the MBTI as a diagnostic tool for instructors and counselors. Another goal was to determine whether the instructional approach used in the experimental course sequence improved the performance of students with specific type preferences in a manner consistent with the following expectations based on type theory:

1. The extensive use of active and cooperative learning in the experimental courses should help both extraverts and feelers, who would not be expected to respond well to traditional instruction that discourages interactions among students.
2. The inductive nature of the experimental course instruction should help sensors, who tend to be disadvantaged when abstract material is not firmly anchored to real-world experience.

The principal results are summarized in this paper. Section II reviews the basic elements of the Theory of Psychological Type that forms the basis of the MBTI and summarizes results from the prior studies of type effects in engineering education. Section III contains demographic data and MBTI preferences of the students in the experimental group, along with data on type differences in their SAT scores, freshman year grades, and scores on the *Learning and Study Strategies Inventory*®. Sections IV and V respectively summarize type differences in the academic performance of the students and in student attitudes and goals. Section VI synthesizes the results and draws inferences regarding the effectiveness of the MBTI as a tool for understanding engineering students and designing effective instruction for them.

A report of all of the observed type differences would be encyclopedic; we will therefore confine the discussion primarily to differences that were significant at the 0.1 level or less (designated with asterisks in the data tables).

II. PSYCHOLOGICAL TYPE AND ENGINEERING EDUCATION

A. A Brief Review of Type Theory

The *Myers-Briggs Type Indicator* measures preferences on four scales derived from Jung's Theory of Psychological Types. People are classified in terms of their preference for

- *introversion* (I) (interest flowing mainly to the inner world of concepts and ideas) or *extraversion* (E) (interest flowing mainly to the outer world of actions, objects, and persons);
- *sensing* (S) (tending to perceive immediate, real, practical facts of experience and life) or *intuition* (N) (tending to perceive possibilities, relationships, and meanings of experiences);
- *thinking* (T) (tending to make judgments or decisions objectively and impersonally) or *feeling* (F) (tending to make judgments subjectively and personally);

- *judging* (J) (tending to live in a planned and decisive way) or
  perceiving (P) (tending to live in a spontaneous and flexible way).

An individual's type is expressed as one of sixteen possible combinations of these preferences. For example, an ENTP would have a preference for extraversion, intuition, thinking, and perception. A preference for one or the other category of a dimension may be mild or strong.

Students with different type preferences tend to respond differently to different modes of instruction.[4,16] Extraverts like working in settings that provide for activity and group work; introverts prefer settings that provide opportunities for internal processing. Sensors like concrete learning experiences and clearly defined expectations and dislike instruction heavy in abstractions like theories and mathematical models; intuitors like instruction that emphasizes conceptual understanding and de-emphasizes memorization of facts, rote substitution in formulas, and repetitive calculations. Thinkers like logically organized presentations of course material and feedback related to their work; feelers like instructors who establish a personal rapport with them and feedback that shows appreciation of their efforts. Judgers like well-structured instruction with clearly defined assignments, goals, and milestones; perceivers like to have choice and flexibility in their assignments and dislike having to observe rigid timelines.

Professionals in every field must function in all type modalities to be fully effective, and the goal of education should therefore be to provide balanced instruction. Students should be taught sometimes in the style they prefer, which keeps them from being too uncomfortable for learning to occur, and sometimes in their less preferred mode, which helps them develop the diverse strengths they will need to function effectively in their careers. Unfortunately, traditional higher education is not structured to provide this balance, and severe mismatches commonly occur between the teaching styles of instructors and the learning styles of their students, with detrimental effects on the academic performance of the students and on their attitudes toward their education.[1–4,16]

B. Type Effects in Engineering Education

In 1980, a consortium consisting of eight universities and the Center for Applications of Psychological Type was formed to study the role of personality type in engineering education. Introverts, intuitors, and judgers generally outperformed their extraverted, sensing, and perceiving counterparts in the population studied.[5,6] In work done as part of this study, Godleski[17] reported on grades in four sections of the introductory chemical engineering course at Cleveland State University taught by three different instructors. The emphasis in this course is on setting up and solving a wide variety of problems of increasing complexity, with memory and rote substitution in formulas playing a relatively small role. Intuitors would be expected to be at an advantage in this course, and the average grade for the intuitors in all sections was indeed higher than that for the sensors. Godleski obtained similar results for other courses that emphasize more intuitive skills, while in the few "solid sensing" courses in the curriculum (such as engineering economics) the sensors scored higher.

Besides being less comfortable than intuitors with abstract material are, the sensors in Godleski's studies may have fared more poorly than the intuitors because problem-solving speed is an important determinant of test grades in many engineering courses. Myers[18] claims that time-bound tests put intuitors at an advantage due to the tendency of sensing types to reread test questions several times before attempting to answer. Wankat and Oreovicz[19] observe that if memorization and recall are important, sensing types should perform better, while if analysis is required, intuitive students should have an advantage.

In a longitudinal study carried out at the University of Western Ontario by Rosati,[7–9] male students with preferences for introversion, intuition, thinking, and judging were found to be more likely to succeed in the first year of the engineering curriculum than were their extraverted, sensing, feeling and perceiving counterparts. Rosati also observed that introverts, thinkers, and judgers were more likely than extraverts, feelers, and perceivers to graduate in engineering after four years, but sensors were more likely than intuitors to do so. These findings only applied to male students at the low end of the academic spectrum: students who came into engineering with strong predictors of success were equally likely to succeed, regardless of their type, and Rosati found no statistically significant filtering by type among the female students.

III. PROFILE OF THE EXPERIMENTAL COHORT

The experimental group consisted of 116 students who took the MBTI near the beginning of the Fall 1990 semester. The students were 70% male and 30% female; 84% percent were white, 6% African-American, 5% Asians or Asian-American, 3% Native American, and 2% Hispanic.

MBTI type distributions are shown in Table 1. The population distributions are similar to those found for 3786 male and 698 female undergraduate engineering students in an eight-university consortium.[6] There were roughly equal numbers of extraverts and introverts, sensors outnumbered intuitors and judgers outnumbered perceivers by ratios of roughly 3:2, and thinkers substantially outnumbered feelers among both males and females with the overall ratio being roughly 7:3. ST was by far the predominant function, accounting for over 40% of both the male and female populations.

A. SAT Scores and Freshman Year Grades

SAT scores were available for 100 students in the study. The only statistically significant type difference in average SAT scores was between sensors and intuitors on the SAT-Math test (645 for intuitors, 615 for sensors, p=.07). The intuitors also outscored the sensors on the SAT-Verbal test by 533 to 511 and perceivers outscored judgers on the SAT-Math test by 642 to 619, but these differences were not statistically significant. Extraverts and introverts scored almost identically on both the mathematics and verbal tests.

Several significant type differences in freshman year academic performance were observed. In overall first-year GPA, intuitors outperformed sensors (3.38 to 3.17, p=.09), thinkers outperformed feelers (3.34 to 3.09, p=.05), and judgers outperformed perceivers (3.37 to 3.10, p=.02). The same type differences were observed in calculus, physics, and chemistry grades. Introverts outperformed extraverts in overall GPA, but the difference was not statistically significant (3.32 to 3.20, p=0.17). The fact that the judgers outscored the perceivers despite the latter group's generally higher SAT scores suggests that task orientation and persistence may count for more than scholastic aptitude in overcoming the challenges of the difficult first year of engineering.

B. Learning and Study Strategies

Table 2 summarizes student responses to the *Learning and Study Strategies Inventory*[20] (LASSI) and briefly defines the nine scales of the inventory. A high score is desirable on each scale of the inventory: for example, if Student A scores higher than Student B on the ATT scale, it indicates that Student A has a more positive attitude toward school and education.

Extraverts scored higher than introverts on every scale of the LASSI, with the differences being statistically significant (p<.1) for general attitudes, anxiety level (a high score indicates low anxiety), concentration, information processing, use of study aids, and self-testing. Judgers scored significantly higher than perceivers in motivation to study, time management (p<.001), concentration, selecting main ideas, use of study aids, and self-testing. The extravert-introvert differences are surprising, since nothing in type theory suggests that extraverts should be better than introverts at such things as time on task and self-testing; in fact, one might expect the opposite. A study to determine whether this result generalizes or (as is likely) is just an artifact of this particular population would be worthwhile.

IV. TYPE DIFFERENCES IN ACADEMIC PERFORMANCE

As previously noted, Rosati[7–9] observed type differences for students at the lower end of the academic spectrum and no discrimination by type for the better students. Prompted by these findings, we used as a measure of academic aptitude the Admissions Index (AI)—a quantity computed on the basis of an entering student's SAT scores, high school grade-point average, and standing in his or her high school graduating class—and computed certain results separately for students with AI≥3.0 and AI<3.0. We will use the terms "stronger students" and "weaker students" to designate these two groups, acknowledging that some individuals within the latter group were quite strong academically and conversely for the former group.

Table 3 shows cumulative grade point averages by type preference in the freshman year (S90), at the end of the first semester of the sophomore year (F90), and at the end of each of the second, third, and fourth years of college. The first-year figures do not include transfer students, who completed part or all of their initial year at some other institution and entered N.C. State in their second year.

In the experimental chemical engineering courses, we examined type differences in several course performance measures: (i) average grade (A=4.0); (ii) percentage passing (defined as getting the grade of C or better required to take the next course in the sequence), and (iii) percentage receiving A's. Selected results for each of the five courses of the experimental sequence are shown in Tables 4–6. (We should note that given the large number of statistical comparisons in Table 4, some differences would be expected to be statistically significant just by chance. Some of the differences shown in Table 4 to be significant could thus represent Type I errors.)

Many of the noteworthy course grade differences observed were in the first course in the experimental sequence, CHE 205 (Chemical Process Principles), which has the somewhat deserved reputation of being the filter for the chemical engineering curriculum. The course material and problem-solving methods introduced in this course are totally new to most students, many of the assigned problems are very long (especially when the students do not adopt a systematic approach to solving them), and the tests emphasize understanding rather than memorization. The passing percentages in experimental courses past the first one were close to 100% in all type categories and so are not reported in the tables.

Besides taking the five experimental courses taught by Dr. Felder, the students in the experimental group took as many as seven other chemical engineering courses taught by other professors. In three of the latter courses—two laboratory courses and the capstone design course—the grades were based entirely on team projects that did not include individual assessment and so provide no basis for determining type effects on individual performance. The other four courses were taught in a traditional manner, with little or no active or cooperative learning. Two of them—CHE 315 (Thermodynamics I) and CHE 316 (Thermodynamics II)—were taken in the third year of the curriculum, and the other two—CHE 425 (Chemical Process Control) and CHE 450 (Chemical Process Design I)—were taken in the fourth year. Table 7 shows performance data for these courses.

Some of the students who enrolled in CHE 205 never intended to major in chemical engineering, but were in curricula such as pulp and paper technology that required them to take the course. Tables 8 and 9 summarize retention and graduation data for the 105 students who took CHE 205 intending to major in chemical engineering.

The sections that follow summarize and discuss the type differences shown in Tables 3–9.

A. Extraverts and Introverts

Among the stronger students, the introverts had a higher average admissions index and a higher freshman year grade-point average than the extraverts (Table 3), with neither difference being statistically significant. The introverts maintained their advantage throughout college in overall GPA (Table 3), performance in chemical engineering courses (Tables 4 and 7), and (very slightly) retention in the chemical engineering curriculum (Table 8), but with the exception of grades in a single course (CHE 315), the differences were not statistically significant. This result (introverts generally doing better than extraverts but the difference not being significant among stronger students) is consistent with Rosati's findings.[7–9]

A completely different picture emerged for the weaker students. The extraverts had a slightly higher average admissions index and the average freshman year GPAs were essentially equal for both (Table 3). The two groups performed at significantly different levels in the introductory chemical engineering course, however, with the extraverts earning almost a full letter grade higher average course grade (2.22 vs. 1.41) and passing the course with a grade of C or better at a much higher rate (73% vs. 44%) (Table 4). The introverted sensors among the weaker students were particularly at risk. By the end of the fifth year 62% of them had dropped out of chemical engineering, as contrasted with 25% of the extraverted intuitors, 27% of the introverted intuitors, and only 11% of the extraverted sensors (Table 9). This result will be discussed further in the next section.

No prior study has shown extraverts doing better than introverts in an engineering curriculum or individual course. Two factors might have contributed to the extraverts' superior performance among the weaker students:

1. *The extraverts may have had better motivation and study habits than the introverts*. The scores on the learning and study strategies inventory (Table 2) support this hypothesis. Extraverts scored significantly higher on six of the ten LASSI scales, including attitude and interest in school, concentration and attention to academic tasks, information processing ability, use of study aids, and self-testing.
2. *The emphasis on active and cooperative learning in the experimental courses may have negated the usual advantage enjoyed by introverts in the traditional approach to engineering education, which emphasizes individual work.*

The speculation that cooperative learning gave the extraverts an advantage over the introverts is consistent with type theory. The traditional mode of engineering instruction, which stresses individual effort and competition for grades, is more compatible with the natural studying tendencies of introverts than of extraverts. Introverts taught traditionally might therefore be expected to outperform extraverts, as they did in the studies of McCaulley *et al*.[6] and Rosati.[7–9] In the experimental courses, the mandated group work in most assignments would be comfortable for the extraverts, while the characteristic shyness of many introverts might have caused some of them to be relatively passive in their groups, depriving them of the full benefits of cooperative learning.

B. Sensors and Intuitors

Reviewing studies of type effects in education, McCaulley[21] reports the sensing-intuition difference to be "by far the most important of the preferences." Godleski[17] found that intuitors among engineering students consistently outperformed sensors except in "real-world" courses like process design and cost estimation, in which the sensors did better. Rosati found that intuitors outperformed sensors early in the curriculum,[7] but noted that the difference was significant only among academically weaker male students, and he found that sensors were slightly more likely than intuitors to graduate in four years.[9]

The results of our study are generally consistent with these observations, except that a few noteworthy differences in course performance were also observed among the stronger students. The stronger sensors earned a higher grade point average than their intuitive counterparts in their freshman year and maintained their advantage thereafter, but the differences were not statistically significant and might simply reflect the higher admissions index of the sensing group (Table 3). Both types performed comparably in the introductory course; the intuitors earned higher grades in CHE 311 (Table 4, not significant) and CHE 316 (Table 7, significant), arguably the most abstract and mathematical chemical engineering courses in the curriculum, and the sensors earned higher grades in CHE 225, the least abstract of all the courses (Table 4, significant).

The results for the weaker students were much different. Although the sensors and intuitors had almost identical admissions indices, the intuitors maintained significantly higher GPAs than the sensors throughout college (Table 3) and did better in every chemical engineering course, with the differences being significant in CHE 205 and CHE 311 (Table 4). As noted previously, introverted sensors generally earned much lower grades and were much less likely to graduate in chemical engineering than introverted intuitors, extraverted sensors, and extraverted intuitors. Intuitive judgers earned much higher grades than intuitive perceivers and both judging and perceiving sensors (Table 6). Sensor/intuitor differences in retention were not statistically significant for either the stronger or the weaker students (Table 8). Among the stronger students the retention was higher for the sensors, a result consistent with a finding of Rosati[9] and with the sensors' higher average admissions index and first-year GPA (Table 3).

Prior studies of type effects in engineering education (e.g., Godleski[17]) suggest that traditional instruction in most courses emphasizes the theoretical over the practical and so gives intuitors an advantage over sensors. The experimental courses were designed to provide greater balance by strengthening coverage of practical aspects of the course content. The effort may not have been enough to help the weaker sensors earn grades as high as the intuitors earned, but it may have helped to reduce their traditionally higher dropout rate. The fact that in their last year 82% of the sensors found the experimental courses "much more instructive" than their other chemical engineering courses (as opposed to 62% of the intuitors who felt that way) supports this speculation.

The extensive use of cooperative learning in the experimental courses may help to explain the relatively high dropout rate of the introverted sensors early in the curriculum relative to that of the extraverted sensors (Table 9). The generally superior performance of students taught cooperatively relative to that of students taught traditionally has been documented in numerous studies,[22,23] but to achieve the full benefits of the cooperative learning students must take an active role within their study teams. Extraverts on cooperative learning teams would characteristically tend to interact with teammates, while many introverts might hang back until they become accustomed to the team interactions, and some might always remain passive. One might speculate that working in teams helped the extraverted sensors among the weak students enough to prevent the high attrition that previous studies have found among sensors. On the other hand, the more passive introverted sensors did not receive the same benefit and so did significantly worse than their intuitive counterparts, a result consistent with the prior studies.

C. Thinkers and Feelers

Although thinkers and feelers began college with similar academic credentials, the thinkers in both the strong and weak categories earned significantly higher grade-point averages in the freshman year and maintained or increased their advantage thereafter (Table 3). This finding is consistent with those of prior studies.[6–9,17]

In chemical engineering course grades and retention in the curriculum, on the other hand, a pattern was observed unlike anything observed in the prior studies—namely, the thinker-feeler differences were more pronounced among the *stronger* students. The grade differences between the stronger thinkers and the stronger feelers were particularly dramatic in CHE 205, CHE 315, and CHE 446 (Tables 4 and 7); moreover, only 4% of the thinkers left chemical engineering during the five years of the study while 11% of the feelers did so after the second year and another 17% did so after the third year (Table 8).

Among the weaker students, no consistent T-F differences were observed: the feelers did marginally better in some courses (including CHE 205), the thinkers did better in others, and there was no real difference in the remaining ones (Tables 4 and 7). Surprisingly, there was not much difference in retention between the two groups: by the end of the third year of college more thinkers than feelers had left chemical engineering and after five years more feelers than thinkers had left, but the differences were not significant (Table 8). Most of the feelers among the weaker students who left did so after four years.

It appears from these results that thinkers who dropped out of chemical engineering did so primarily because of poor grades (an indication being that almost none of the stronger thinkers dropped out), while at least in the first few years feelers left for a variety of reasons, poor grades being just one of them. These results are consistent with type theory, which suggests that the relatively impersonal nature of the engineering curriculum would be comfortable for thinkers and problematic for feelers, some of whom might be inclined to switch to other curricula even if they were doing well academically.

We have noted elsewhere[12] that women in the longitudinal study earned lower grades and suffered greater losses of confidence and higher attrition rates than men. Table 5 shows that the gender effect may be strongly mediated by type: the male thinkers only slightly outperformed the female thinkers in the experimental engineering courses but the male feelers considerably outperformed the female feelers. In all five experimental courses, only one A was earned by a female feeler! The implication is that women with a preference for feeling on the MBTI may be particularly vulnerable in engineering school, perhaps suggesting the need for a better balance in the curriculum between technical and social aspects of engineering.

D. Judgers and Perceivers

The large credit-hour requirements and heavy homework loads that characterize the engineering curriculum make staying on task and managing time effectively prerequisites to success. Type theory suggests that judgers—who are characteristically better at both—should on average outperform perceivers in the undergraduate curriculum. This expectation was borne out by many of the results of this study. (The strengths of perceivers, such as flexibility and tendency to avoid premature closure in problem solving, may provide them with compensatory advantages in research, a hypothesis well worth testing.)

On the LASSI (Table 2), the judgers scored significantly higher than the perceivers in diligence and self-discipline (MOT), time management (TMT), attention to academic tasks (CON), and several measures related to study skills, and came out about the same as the perceivers on the other scales. Among the stronger students, the judgers began with a higher admissions index, earned a higher average first-year GPA, and steadily increased their advantage as they proceeded through the curriculum, always at a statistically significant level (Table 3). The judgers did better than the perceivers in the chemical engineering courses as well, but the differences—although consistent and considerable—were only statistically significant in CHE 311 among the experimental courses (Table 4) and CHE 315 among the non-experimental courses (Table 7). The greatest differences were in the percentages of A's earned by the stronger judgers and perceivers: the difference was as high as 34% in the experimental courses (52% of the judgers and 18% of the perceivers in CHE 311) and 40% in the non-experimental courses (40% of the judgers and none of the perceivers in CHE 450). The retention and graduation rates were also higher for the stronger judgers, but the differences were not significant (Table 8).

The weaker judgers had the same first-year advantage over their perceiving counterparts, but in Years 2–4 there were almost no J-P differences in GPA or performance in CHE 205 among the weaker students. The weaker judgers did substantially better than the weaker perceivers in most of the rest of the remaining chemical engineering courses, however, with average grades almost a half-letter grade higher and much higher percentages of A's. There were no differences worth noting in retention and graduation of the two groups. An implication of the results for both the stronger and weaker students is that the perceivers were as capable of completing the curriculum as the judgers, but the superior task commitment and time management skills of the judgers better equipped them to do what it took to earn high course grades.

Type Interactions

The interactions between the judging–perceiving preference and the sensing–intuitive dimension are striking. Of the 116 students for whom grades were recorded in CHE 205, 76% of the intuitive judgers (NJ), 43% of the intuitive perceivers (NP), 43% of the sensing judgers (SJ), and 31% of the sensing perceivers (SP) completed all five courses in the experimental sequence (Table 6). The results for CHE 205 in particular provide a particularly dramatic illustration of type effects on academic performance: roughly speaking, the average grade was B for the NJs, B–/C+ for the NPs, C for the SJs, and C–/D+ for the SPs. Ninety percent of the NJs passed the course with a C or better, as opposed to 56% of the SPs. The percentage receiving A's varied from 43% for the NJs to 6% for the SPs. In subsequent courses the NJs consistently performed at the highest level relative to the other type categories and the SPs occupied the lowest position in all courses but CHE 312, in which they outscored the NPs. The differences were generally most pronounced among the weaker students.

The large difference between the five-year attrition rates of extraverts (17%) and introverts (48%) with AI<3 may be the most surprising result obtained in this study, considering the consistently superior performance of introverts in prior studies of type differences in engineering.[7,9] A possible explanation is suggested by the observation that the attrition rate of the introverted sensors was 62% and that of the introverted intuitors was only 27% (Table 9). Most of the introverts who left were thus sensors, the type preference historically found to be at greatest risk in engineering.[6,17] On the other hand, contrary to expectations, the extraverted sensors with AI<3 dropped out to an even lower extent (11%) than either extraverted intuitors (25%) or introverted intuitors (27%). We can think of no plausible explanation of this result.

V. TYPE DIFFERENCES IN ATTITUDES AND PLANS

Classes in the experimental courses consisted of lectures with interspersed small group in-class exercises and weekly or (in CHE 205) triweekly group homework assignments. At several stages of the curriculum the students were asked to rate the helpfulness of each of these modes of instruction. Most students responded positively to all three modes, and type differences are seen only in the percentages giving each mode the highest possible rating ("extremely valuable" in CHE 205 and CHE 311, and "Very helpful" in the senior questionnaire). The modes were rated independently, not competitively, so students could give the top rating to any or all of them. The students who remained in the experimental course sequence generally viewed both lectures and group work increasingly positively as they progressed through the curriculum (Table 10). Group homework was regarded as most helpful, followed by lectures and in-class group work.

As juniors and seniors, the students were asked to rate their problem-solving abilities. There were no noteworthy type differences in ratings of ability to solve routine engineering problems, but significant differences emerged when sensors and intuitors rated their abilities to solve problems requiring creativity, with higher percentages of intuitors consistently giving themselves high ratings (Table 11).

In both their sophomore and senior years, the students were asked about their preferred career environments, with the choices being large corporation, small firm, university or research facility, and public service. Table 12 shows the responses of sensors and intuitors, the only type dimension that yielded noteworthy differences. As juniors and seniors, the students were asked about their post-graduation plans (graduate school immediately or later, enter a profession, or take a year off) and responded as shown in Table 13, and the seniors were asked to rate the importance of several characteristics of their first job, with the results shown in Table 14.

The students were also asked in their junior and senior years to choose the most probable explanations of their doing (a) better and (b) worse than expected in the course they were then taking. Possible attributions of success were either internal (real ability or hard work) or external (help from someone else, group work, or luck), and possible attributions of failure were also internal (lack ability, don't work hard enough) or external (course too demanding, personal problems, tests/grading unfair). Although type differences in attributions might have been anticipated,[24] none were observed.

A. Extraverts and Introverts

The differences in the attitudes of extraverts and introverts toward the different modes of instruction used in the experimental courses (Table 10) are revealing. Throughout the study, higher percentages of introverts found lectures extremely helpful to their learning, a result consistent with type theory. On the other hand, the two groups underwent a shift in time regarding their attitudes to group work. As juniors, a moderate percentage of extraverts (16%) and almost no introverts (3%) found in-class group work very helpful; as seniors, the percentage of extraverts rose slightly to 21% and that of introverts increased by an order of magnitude to 33%. Similarly, as sophomores the percentage of extraverts who found group homework very helpful (43%) was greater than the percentage of introverts (33%); the two groups were roughly the same as juniors (65% of the extraverts and 68% of the introverts); and as seniors, more of the introverts found group homework very helpful (88% of the introverts and 70% of the extraverts).

These results have several possible interpretations.

1. Disproportionate numbers of introverts hostile to group work were among those who dropped out of the experimental course sequence between the sophomore and senior years.
2. Early in the study the introverts were characteristically less comfortable than the extraverts with group work, but over time familiarity with their classmates and with the process overcame their objections. Eventually many of them came to appreciate that group work—which they (unlike the extraverts) would have been inclined to avoid if given the choice—helped their mastery of difficult engineering course material.
3. The introverts recognized that they were building an important skill that they tended to be weak in.

The data do not allow us to assess the validity of each of these interpretations, as much as we would like to believe the second and third ones.

As Table 14 shows, having job security was very important to more introverts (62%) than extraverts (43%) and having the chance to do socially important or beneficial work was either very important or fairly important to more extraverts (97%) than introverts (72%). Having opportunities for teamwork was of roughly equal importance to both types, although the extraverts might have been expected to find this feature more attractive. This result may reflect the introverts' increasingly positive response to group work as they progressed through the sequence of experimental courses.

B. Sensors and Intuitors

While both sensors and intuitors appreciated the benefits of cooperative learning, there were significant differences in their perceptions of the principal benefits of this instructional approach. In CHE 311, 52% of the 31 sensors and only 16% of the 31 intuitors felt that the greatest benefit was helping them complete the homework, while 74% of the intuitors and 48% of the sensors felt that the greatest benefit was helping them understand the class material. (The remaining 10% of the intuitors thought the greatest benefit was helping them prepare for the tests.) The different response patterns of the two groups are consistent with type theory.

One noteworthy sensor-intuitor difference emerged when seniors were asked how instructive the experimental courses were compared to other chemical engineering courses they had taken. The responses of the 35 sensors and 32 intuitors were as follows.

Much more instructive:	S – 83%,	N – 62%
Somewhat more instructive:	S – 17%,	N – 22%
About equally instructive:	S – 0%,	N – 16%

No students thought the experimental courses were less instructive. The difference between the sensing and intuitive responses is significant at the .03 level (Fisher exact test). These results may reflect the traditionally heavy emphasis on theory and mathematical modeling in the chemical engineering courses taken outside of the experimental sequence. Sensors tend to be uncomfortable with abstraction, and the deliberate attempt to balance the concrete and the abstract in the experimental courses might have made those courses relatively appealing to them. Some of the intuitors—who are more comfortable with abstraction—might have been expected to find the non-experimental courses comparable in instructional value to the experimental courses, as proved to be the case.

Self-ratings of creative problem-solving ability were consistently higher for intuitors than for sensors (Table 11), another result consistent with type theory. The ratings for both types rose from the second semester of the junior year (Spring 1992), when 61% of the intuitors and only 34% of the sensors rated themselves as “excellent” or “good,” to the second semester of the senior year (Spring 1993), when 81% of the intuitors and 69% of the sensors put their creative problem-solving abilities in one or the other category. Practice and feedback in such problems was a regular feature of the experimental courses, which might account for the rise in self-ratings observed for both groups.

As both sophomores and seniors, a majority of the sensors indicated a desire to work for a large corporation while substantially higher percentages of the intuitors in both years wanted to work for a small firm, a university or research facility, or in public service (Table 12). Intuitors were more inclined than sensors to go to graduate school immediately or eventually (71% vs. 59% as juniors, 54% vs. 39% as seniors).

Meeting or exceeding employers’ expectations in their careers was very important to more sensors (81%) than intuitors (52%), and having a high salary was very important to twice as many sensors (32%) as intuitors (16%) (Table 14). Perhaps the most pronounced and predictable difference in Table 14 had to do with the opportunity to do creative/innovative work, which was very important to more than three times as many intuitors (65%) as sensors (19%). Having good relations with coworkers was considered very important by all but one sensor (97%) and by three-quarters of the intuitors (74%). The absences of certain differences are also noteworthy. Having well defined tasks that don’t change frequently might have been expected to appeal more to sensors than intuitors and having variety in job tasks might have been expected to be more appealing to intuitors, but neither expectation was realized.

C. Thinkers and Feelers

The only significant attitude difference observed between thinkers and feelers was that as seniors, thinkers were more inclined than feelers to go to graduate school (53% vs. 27%) (Table 13). A predictable but not statistically significant difference was that feelers attached greater importance than thinkers to doing socially important/beneficial work (Table 14).

Surprisingly, no noteworthy T-F differences were found in the rated helpfulness of group work (Table 10) or the rated importance in the senior year of meeting or exceeding employers’ expectations, having opportunities for teamwork, and having good relations with coworkers. We might speculate that some feelers to whom these considerations were very important dropped out of the curriculum before the surveys were administered, which could account in part for the absence of the expected differences among the seniors.

D. Judgers and Perceivers

More judgers than perceivers found lectures extremely helpful to their learning (Table 10), with the differences early in the curriculum being statistically significant. This result is consistent with type theory, considering the high level of structure associated with lectures. An interesting type difference was that 28% of the judgers and only 5% of the perceivers in the senior year believed they did more than their fair share in group work, while 13% of the judgers and 29% of the perceivers believed they did *less* than their fair share. Whether these different beliefs were justified is an intriguing but unanswerable question.

A characteristic type difference was in the number of students planning to take a year off after graduation before either going to graduate school or getting a job (Table 13). As might be expected, judgers did not find this option attractive: only one of them selected it in the junior year and none did in the senior year. On the other hand, 10% of the perceiving juniors favored it and the figure went up to 14% in the senior year, more than double the value for any other type preference.

The principal judger-perceiver differences in criteria for job satisfaction (Table 14) were meeting or exceeding employers’ expectations (judgers–76%, perceivers–48%) and having job security (judgers–61%, perceivers–38%).

VI. INFERENCES AND CONCLUSIONS

Engineers may work in experimental or theoretical research, design, development, planning, production, marketing, sales and service, economics, and management. Individuals with different learning styles may be more naturally skilled or comfortable in certain of these functions than in others, but individuals of all styles can flourish in any of them.

Moreover, to function successfully as an engineer in any capacity, individuals must develop skills characteristic of all learning style categories. For example, they must approach some tasks carefully, systematically, and observantly, attending to small details and replicating measurements or calculations enough to have confidence in the results. This is the characteristic approach of the sensor: intuitors can learn to do it, but it does not come naturally to them. Engineers must also go beyond the immediacy of the data, attempting to understand it in light of current knowledge about the subject and exploring its possible implications. Intuitors are characteristically far more inclined to do that sort of thing than sensors are, although sensors can learn to do it. Similarly, engineers should make decisions taking into account both logic and regulations (as thinkers tend to do) and subjective human considerations (as feelers tend to do), and so on.

The point of using learning styles in teaching is therefore not to determine each student's preferred instructional approach (visual or verbal, concrete or abstract, etc.) and teach exclusively in that manner. It is rather to "teach around the cycle," making sure that every style is addressed to some extent in the instruction. If this is done, then all students will be taught in a manner that (1) addresses their preferences part of the time, keeping them from becoming so uncomfortable that they cannot learn, and (2) requires them to function in their less preferred modes part of the time, helping them to develop skills in those modes.[3] Which of the dozens of existing learning style models is used as a basis for the instructional design is almost irrelevant. As long as each category of the chosen model is addressed part of the time, the teaching is certain to be more effective than it is when some categories are routinely ignored.

The questions that we wished to examine in this study are first, is the Myers-Briggs Type Indicator an effective tool for assessing engineering students' learning style preferences, and second, does an active, cooperative, and inductive instructional model successfully correct the biases of the traditional instructional model against students with specific preferences? We will discuss each question in turn.

A. Efficacy of the Myers-Briggs Type Indicator for Characterizing Engineering Students

While the results of this study cannot be said to formally validate the Myers-Briggs Type Indicator as a personality type or learning style assessment tool for engineering students, many of them are consistent with expectations based on type theory.[4] To name a few,

- Intuitors performed significantly better than sensors in courses with a high level of abstract content and the contrary was observed in courses of a more practical nature.
- Thinkers consistently outperformed feelers in the relatively impersonal environment of the engineering curriculum, and feelers were more likely to drop out of the curriculum even if they were doing well academically.
- Faced with the heavy time demands of the curriculum and the corresponding need to manage their time carefully, judgers consistently outperformed perceivers.
- Extraverts reacted more positively than introverts when first confronted with the requirement that they work in groups on homework.
- The majority of sensors intended to work as engineers in large corporations while a much higher percentage of intuitors planned to work for small companies or to go to graduate school and work in research.

- Intuitors were three times more likely than sensors to give themselves top ratings for creative problem-solving ability and to place a high value on doing creative or innovative work in their careers.
- Feelers placed a higher value on doing socially important or beneficial work in their careers than thinkers did.
- As seniors, 14% of the perceivers and none of the judgers planned to take a year off following graduation before committing themselves to a career direction.

There were very few results that contradicted expectations from type theory, and most of those were in the nature of differences that might have been expected to show up in the data but did not. Our conclusion is that the MBTI effectively characterizes differences in the ways engineering students approach learning tasks, respond to different forms of instruction and classroom environments, and formulate career goals.

This is not to say that the MBTI provides a picture of students complete enough to predict their success or failure in a given course or curriculum. No learning style model or assessment tool can make that claim. How students perform in a course is determined by an uncountable number of factors, including motivation for taking the course, understanding of the course prerequisites, attitude toward the subject, native intelligence, current physical and emotional condition, self-confidence, concurrent academic and nonacademic demands on their time, personal rapport with the instructor and with classmates, *and* compatibility between their learning style and the instructor's teaching style. The four letters of a student's MBTI profile may offer useful clues about the last of these factors but nothing more than that, and even the clues are open to question. The fact that a student has a strong preference for sensing over intuition, for example, provides little indication of his or her ability to function in an intuitive mode—or in a sensing mode, for that matter. Furthermore, important aspects of learning style are not directly addressed by the MBTI, including preference for visual or verbal presentation of information or inclination to approach learning tasks in a sequential (or linear or left-brained) or global (or holistic or random or right-brained) manner, preferences that are addressed by other assessment tools.[3]

In short, we believe that the MBTI can provide useful insights into students' learning strengths and weaknesses, but we strongly caution against using it to discourage a student from pursuing engineering or any other curriculum or career. Such a use is unwarranted and unethical.

B. Efficacy of the Experimental Instructional Approach

Prior studies of type effects in engineering education have shown that introverts typically outperform extraverts, intuitors outperform sensors, thinkers outperform feelers, and judgers outperform perceivers.[6,7–9,17] Our hypotheses were that using active group exercises in class and cooperative learning groups for homework would help overcome the extraverts' and feelers' historical disadvantage, and using an inductive teaching approach (progressing from the concrete to the abstract and anchoring theoretical course material with real-world examples whenever possible) would do the same for the sensors.

If the study data support these hypotheses (as in fact they do), an obvious question is whether it is because the experimental instruction helped the historically disadvantaged types or hurt the advantaged types. The extensive research base supporting active, cooperative, and inductive teaching methods[19,22,23] and the fact that the graduation rate in engineering of the experimental cohort was significantly greater than that for a traditionally-taught comparison group[14] suggest the validity of the former interpretation.

Comparisons of the academic performance of the extraverts and introverts suggest that the experimental instruction did indeed eliminate the historical advantage enjoyed by introverts in engineering education. Among the students at greatest risk (with admissions indices less than 3.0), the extraverts and introverts had almost identical grade-point averages in their first year of college, but more than half of the introverts and only about one-quarter of the extraverts earned D's or F's in the first chemical engineering course. The extraverts who remained in the experimental sequence either outperformed the remaining introverts or performed at a comparable level in subsequent chemical engineering courses. After five years of college, 80% of the extraverts who began the experimental course sequence had graduated in chemical engineering while roughly half of the introverts in the cohort had dropped out of the curriculum.

The introductory chemical engineering course generally functions as a curricular filter: if students pass it with a grade of C or better, the chances are good that they will complete the rest of the curriculum. We have speculated that in their initial exposure to group work in the first course, the academically weaker introverts were likely to be less active in their groups, receiving fewer of the learning benefits known to be provided by cooperative learning[21] and earning lower grades than the extraverts. Later in the curriculum, the introverts who survived the first course were more comfortable with group work and appreciative of its benefits (as their survey responses indicated), and so neither group had an advantage over the other.

We cannot attribute the superior performance of the extraverts in the introductory course entirely to the use of cooperative learning in that course: scores on the Learning and Study Strategies Inventory indicate that coming into the course the extraverts on average had greater study skills and better attitudes toward school. Recall, however, that introverts have outperformed extraverts in all prior studies of type effects in engineering education and that the systematic use of group work is the only feature of the instructional approach in this study that could be expected to favor extraverts over introverts. These observations lend strong support to the hypothesis that cooperative learning was a major contributing factor to the extraverts' superior performance, if not the primary factor.

The degree to which the experimental approach leveled the playing field for sensors and intuitors is less clear. The academically weaker intuitors as a group did significantly better than their sensing counterparts in the first year of college and continued to earn higher grades in most chemical engineering courses. There was essentially no noteworthy difference in attrition, however; and the four-year graduation rate of the weaker sensors was actually higher than that for the intuitors. Moreover, 100% of the sensors rated the experimental courses as more instructive than other chemical engineering courses they had taken while 84% of the intuitors did so, a statistically significant difference. In summary, while we may not have proved that the experimental instructional approach successfully overcame the bias toward intuitors that characterizes the traditional approach in engineering, we feel justified in claiming that it represents a step in the right direction.

A different set of issues arises from a comparison of the grade distributions and retention rates of thinkers and feelers. First, the difference in chemical engineering course grades appears to be strongly gender-related: male feelers did as well as or better than male and female thinkers, but female feelers consistently earned lower grades than students in the other three categories. Second, the attrition of thinkers tended to be closely related to academic performance and limited almost entirely to the weaker students, while both strong and weak feelers dropped out, and the strong ones tended to do so early in the curriculum. The implication is that feelers who drop out are as likely to do because they don't like the courses as for reasons of academic difficulty.

A likely cause of a negative attitude toward engineering in feelers—especially female feelers—is the relatively impersonal nature of the engineering curriculum.[21] In practice, engineering is rich in socially important applications, and communication and interpersonal skills are often more important for career success than technical knowledge, especially after the first job. These ideas are not well communicated in the traditional engineering curriculum, however, which could account for a large part of the chronic difficulty in recruiting and retaining women in engineering. Incorporating a broader range of material related to environmental engineering, biotechnology, and engineering ethics into the lectures and homework problems would probably have made the course a better learning experience for all of the students and might have made the subject more appealing to the feelers.

We had hoped that the use of cooperative learning in the experimental courses would make the classes more supportive to feelers in general and women in particular, and indeed it may have; however, cooperative learning can be a two-edged sword for women in engineering, some of whom are discounted or ignored within their groups.[12] One way of improving the situation for women might be to avoid teams consisting of one woman and two or three men[25]; another would be to orient the students at the beginning of the course to the problems faced by women and minorities in engineering.

The advantage of the judgers over the perceivers observed in previous studies was also observed in this one, but only through grade differences that were at most marginally significant. Among the stronger students a higher percentage of perceivers than of judgers left chemical engineering but the difference was not significant, and there was virtually no difference between the attrition rates of judgers and perceivers among the weaker students. Modifications in instruction to accommodate the needs of perceivers would include giving more open-ended problems that require flexible thinking—including design problems—and possibly training sessions in effective time management techniques.[21]

A final step that might be taken by instructors would be to become familiar through workshops or self-study with the strengths and weaknesses of students of all MBTI types and the teaching methods to which students of each type respond best. It is not necessary to know the profiles of the individual students in a class to make use of this information; it suffices to know that students of all types are probably represented. If instructors try to address each type category at least part of the time, the chances are good that the quality of their teaching will improve.

ACKNOWLEDGMENTS

This work was supported by National Science Foundation Undergraduate Curriculum Development Program Grants USE-9150407-01 and DUE-9354379 and by the SUCCEED Coalition (NSF Cooperative Agreement EEC-9727411). We acknowledge with gratitude the contributions of Lynne Baker-Ward to the student survey design and the statistical analyses performed by Meredith Mauney, Diane Hall, and Cralen Davis.

REFERENCES

1. Felder, R.M., and L.K. Silverman, "Learning and Teaching Styles in Engineering Education," *Engineering Education,* vol. 78, 1988, pp. 674–681.
2. Felder, R.M., "Reaching the Second Tier: Learning and Teaching Styles in College Science Education," *Journal of College Science Teaching,* vol. 23, no. 5, 1993, pp. 286–290.
3. Felder, R.M., "Matters of Style," *ASEE Prism*, vol. 6, no. 4, pp.18–23.
4. Lawrence, G., *People Types and Tiger Stripes*, 3rd Edition, Center for Applications of Psychological Type, Gainesville, FL, 1994.
5. McCaulley, M.H., E.S. Godleski, C.F. Yokomoto, L. Harrisberger, and E.D. Sloan, "Applications of Psychological Type in Engineering Education," *Engineering Education*, vol. 73, 1983, pp. 394–400.
6. McCaulley, M.H., G.P. Macdaid, and J.G. Granade, "ASEE-MBTI Engineering Consortium: Report of the First Five Years," *Proceedings,1985 ASEE Annual Conference*, ASEE, 1985.
7. Rosati, P., "Student Retention from First-Year Engineering Related to Personality Type," *Proceedings,1993 Frontiers in Education Conference*, IEEE, 1993.
8. Rosati, P., "Psychological Types of Canadian Engineering Students," *Journal of Psychological Type,* vol. 41, 1997, pp. 33–37.
9. Rosati, P., "A Personality Type Perspective of Canadian Engineering Students," *Proceedings, Annual Conference of the Canadian Society of Civil Engineering*, CSCE, 1999.
10. Felder, R.M., K.D. Forrest, L. Baker-Ward, E.J. Dietz, and P.H. Mohr, "A Longitudinal Study of Engineering Student Performance and Retention. I. Success and Failure in the Introductory Course," *Journal of Engineering Education*, vol. 82, no. 1, 1993, pp. 15-21.
11. Felder, R.M., P.H. Mohr, E.J. Dietz, and L. Baker-Ward, "A Longitudinal Study of Engineering Student Performance and Retention. II. Differences between Students from Rural and Urban Backgrounds," *Journal of Engineering Education,* vol. 83, no. 3, 1994, pp. 209-217.
12. Felder, R.M, G.N. Felder, M. Mauney, M., C.E. Hamrin, Jr., and E.J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes, *Journal of Engineering Education,* vol. 84, no. 2, 1995, pp. 151–174.
13. Felder, R.M., "A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Student Responses to Them," *Journal of Engineering Education,* vol. 84, no. 4, 1995, pp. 361–367.
14. Felder, R.M., G.N. Felder, and E.J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. V. Comparisons with Traditionally-Taught Students," *Journal of Engineering Education,* vol. 87, no. 4, 1998, pp. 469-480.
15. Myers, I.B., and M.H. McCaulley, *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator,* Consulting Psychologists Press, Palo Alto, CA, 1985.
16. Felder, R.M., (a) "Meet Your Students. 1. Stan and Nathan," *Chemical Engineering Education,* vol. 23, no. 2, 1989, pp. 68–69; (b) "Meet Your Students. 4. Jill and Perry," *Chemical Engineering Education,* vol. 25, no. 4, 1991, pp. 196–197; (c) "Meet Your Students. 5. Edward and Irving," *Chemical Engineering Education,* vol. 28, no. 1, 1994, pp. 36–37; (d) "Meet Your Students. 6. Tony and Frank," *Chemical Engineering Education,* vol. 29, no. 4, 1995, pp. 244–245.
17. Godleski, E.S., "Learning Style Compatibility of Engineering Students and Faculty," *Proceedings, 1984 Frontiers in Education Conference*, IEEE, 1984.
18. Myers, I.B., *Gifts Differing*, Consulting Psychologists Press, Palo Alto, CA, 1980.

19. Wankat, P., and F. Oreovicz, *Teaching Engineering,* McGraw-Hill, New York, 1993, p. 253.

20. Weinstein, C.E., *LASSI Users Manual,* H&H Publishers, Clearwater, FL, 1987.

21. McCaulley, M.H., "The MBTI and Individual Pathways in Engineering Design," *Engineering Education*, vol. 80, 1990, pp. 537–542.

22. Johnson, D.W., R.T. Johnson, and K.A. Smith, *Active Learning: Cooperation in the College Classroom,* 2nd Edition, Interaction Book Company, Edina, MN, 1998.

23. Springer, L., M.E. Stanne, and S. Donovan, "Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis," <*http://www.wcer.wisc.edu/nise/CL1/CL/resource/R2.htm*>, 1998.

24. Thomson, N.F., and M.J. Martinko, "The Relationship between MBTI Types and Attributional Style," *Journal of Psychological Type,* vol. 35, 1995, pp. 22–30.

25. Felder, R.M., and R. Brent, *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs*, ERIC Document Reproduction Service, ED-377038, 1994.

LIST OF TABLES

TABLE 1
MBTI TYPE DISTRIBUTIONS

Females (n=34)							
ISTJ	26.5%	ISFJ	5.9%	INFJ	5.9%	INTJ	5.9%
ISTP	0.0%	ISFP	2.9%	INFP	0.0%	INTP	2.9%
ESTP	2.9%	ESFP	0.0%	ENFP	14.7%	ENTP	0.0%
ESTJ	14.7%	ESFJ	11.8%	ENFJ	2.9%	ENTJ	2.9%
50.0% E	–	50.0% I					
64.7% S	–	35.3% N		44.1% ST		20.6% SF	
55.9% T	–	44.1% F		11.8% NT		23.5% NF	
76.5% J	–	23.5% P					

Males (n=82)							
ISTJ	18.3%	ISFJ	4.9%	INFJ	1.2%	INTJ	8.5%
ISTP	4.9%	ISFP	1.2%	INFP	2.4%	INTP	11.0%
ESTP	8.5%	ESFP	2.4%	ENFP	7.3%	ENTP	6.1%
ESTJ	9.8%	ESFJ	4.9%	ENFJ	1.2%	ENTJ	7.3%
47.6% E	–	52.4% I					
54.9% S	–	45.1% N		41.5% ST		13.4% SF	
74.4% T	–	25.6% F		32.9% NT		12.2% NF	
56.1% J	–	43.9% P					

Total (n=116)							
ISTJ	20.7%	ISFJ	5.2%	INFJ	2.6%	INTJ	7.8%
ISTP	3.4%	ISFP	1.7%	INFP	1.7%	INTP	8.6%
ESTP	6.9%	ESFP	1.7%	ENFP	9.5%	ENTP	4.3%
ESTJ	11.2%	ESFJ	6.9%	ENFJ	1.7%	ENTJ	6.0%
48.3% E	–	51.7% I					
57.8% S	–	42.2% N		42.2% ST		15.5% SF	
69.0% T	–	31.0% F		26.7% NT		15.5% NF	
62.1% J	–	37.9% P					

TABLE 2
LEARNING AND STUDY STRATEGIES INVENTORY SCORES

Scale	E (55)	I (57)	$p^†$	J (71)	P (41)	$p^†$
ATT	33.8	31.2	.02*	32.8	31.9	.42
MOT	32.3	31.7	.54	33.2	29.9	.001*
TMT	25.1	24.5	.55	26.2	22.3	.001*
ANX	26.9	24.0	.03*	25.2	25.8	.71
CON	28.2	26.2	.06*	28.1	25.5	.02*
INP	29.7	26.9	.006*	28.1	28.6	.61
SMI	19.5	18.9	.38	19.6	18.5	.09*
STA	26.9	23.9	.06*	25.5	23.7	.08*
SFT	26.9	25.2	.09*	26.7	24.9	.08*
TST	31.1	29.5	.14	30.6	29.6	.35

ATT: Attitude and interest in school
MOT: Motivation, diligence, self-discipline, willingness to work hard
TMT: Use of time management principles for academic tasks
ANX: Anxiety about school performance
CON: Concentration and attention to academic tasks
INP: Information processing (ability to supply meaning and organization to new information)
SMI: Selecting main ideas and recognizing important information
STA: Use of study aids (highlighting, underlining, writing summaries,...)
SFT: Self-testing, reviewing, preparing for classes
TST: Test-taking strategies and preparing for tests

† Wilcoxon rank-sum test

TABLE 3
CUMULATIVE GPA BY TYPE
PREFERENCE AND SEMESTER

STUDENTS WITH AI≥3

	E	I	$p^{\dagger}$	S	N	$p^{\dagger}$	T	F	$p^{\dagger}$	J	P	$p^{\dagger}$
AI[a]	3.19	3.25	.16	3.27	3.18	.04*	3.23	3.21	.80	3.26	3.16	.03*
(n)	(19)	(26)		(21)	(24)		(27)	(18)		(28)	(17)	
GPA												
S90[b]	3.50	3.63	.27	3.64	3.52	.32	3.66	3.45	.08*	3.65	3.45	.10*
(n)	(18)	(26)		(21)	(23)		(27)	(17)		(28)	(16)	
F90[c]	3.34	3.56	.12	3.55	3.39	.24	3.59	3.28	.02*	3.58	3.27	.03*
S91	3.31	3.53	.12	3.54	3.35	.21	3.57	3.24	.02*	3.58	3.20	.01*
S92	3.31	3.52	.13	3.51	3.37	.31	3.54	3.27	.05*	3.58	3.20	.01*
S93	3.34	3.55	.11	3.55	3.39	.22	3.57	3.30	.04*	3.60	3.23	.004*
(n)	(19)	(26)		(21)	(24)		(27)	(18)		(28)	(17)	

STUDENTS WITH AI<3

	E	I	$p^{\dagger}$	S	N	$p^{\dagger}$	T	F	$p^{\dagger}$	J	P	$p^{\dagger}$
AI[a]	2.62	2.51	.17	2.58	2.56	.74	2.59	2.53	.50	2.61	2.52	.21
(n)	(28)	(24)		(32)	(20)		(39)	(13)		(30)	(22)	
GPA												
S90[b]	3.02	2.99	.88	2.88	3.21	.05*	3.13	2.65	.01*	3.12	2.86	.13
(n)	(28)	(24)		(32)	(20)		(39)	(13)		(30)	(22)	
F90[c]	3.01	2.63	.02*	2.71	3.05	.04*	2.91	2.60	.09*	2.84	2.81	.83
S91	3.01	2.56	.01*	2.66	3.03	.04*	2.89	2.58	.09*	2.79	2.81	.92
S92	2.97	2.57	.02*	2.66	2.99	.06*	2.84	2.60	.20	2.80	2.74	.71
S93	3.00	2.60	.02*	2.68	3.00	.08*	2.86	2.64	.25	2.84	2.75	.62
(n)	(35)	(32)		(43)	(24)		(50)	(17)		(42)	(25)	

†Wilcoxon rank-sum test
[a]Admissions index (predicted grade-point average prior to enrollment in college)
[b]GPA following the Spring 1990 semester
[c]GPA following the first semester of the study (Fall 1990)

TABLE 4
GRADES IN EXPERIMENTAL CHE COURSES

STUDENTS WITH AI≥3

	E	I	p†	S	N	p†	T	F	p†	J	P	p†
CHE 205	(19)	(26)		(21)	(24)		(27)	(18)		(28)	(17)	
Avg. Grade (A=4)	2.95	3.19	.46	3.14	3.04	.76	3.41	2.61	.01*	3.25	2.82	.20
% A's	42%	42%	≅1	48%	38%	.56	48%	33%	.37	50%	29%	.22
% pass (A,B,C)	84%	92%	.64	90%	88%	≅1	100%	72%	.01*	93%	82%	.35
CHE 225	(14)	(23)		(18)	(19)		(25)	(12)		(25)	(12)	
Avg. Grade	3.14	3.52	.16	3.61	3.16	.08*	3.48	3.17	.27	3.52	3.08	.12
% A's	43%	61%	.33	61%	47%	.52	56%	50%	≅1	64%	33%	.16
CHE 311	(14)	(20)		(17)	(17)		(22)	(12)		(23)	(11)	
Avg. Grade	3.00	3.15	.63	2.94	3.24	.33	3.18	2.92	.40	3.26	2.73	.09*
% A's	43%	40%	≅1	29%	53%	.30	45%	33%	.72	52%	18%	.08*
CHE 312	(13)	(19)		(15)	(17)		(22)	(10)		(22)	(10)	
Avg. Grade	3.46	3.47	.96	3.67	3.29	.12	3.55	3.30	.35	3.55	3.30	.35
% A's	54%	58%	≅1	67%	47%	.31	64%	40%	.27	64%	40%	.27
CHE 446	(12)	(17)		(14)	(15)		(20)	(9)		(20)	(9)	
Avg. Grade	3.25	3.41	.56	3.36	3.33	.93	3.50	3.00	.08*	3.40	3.22	.55
% A's	50%	47%	≅1	43%	53%	.72	60%	22%	.11	50%	44%	≅1

STUDENTS WITH AI<3

	E	I	p†	S	N	p†	T	F	p†	J	P	p†
CHE 205	(37)	(34)		(46)	(25)		(53)	(18)		(44)	(27)	
Avg. Grade	2.22	1.41	.02*	1.50	2.44	.01*	1.79	1.94	.71	1.86	1.78	.81
% A's	14%	12%	≅1	4%	28%	.007*	15%	6%	.43	14%	11%	≅1
% pass (A,B,C)	73%	44%	.02*	50%	76%	.04*	55%	72%	.27	59%	59%	≅1
CHE 225	(21)	(13)		(17)	(17)		(25)	(9)		(22)	(12)	
Avg. Grade	2.95	2.54	.26	2.76	2.82	.87	2.96	2.33	.12	3.00	2.42	.12
% A's	39%	44%	.81	18%	29%	.69	29%	11%	.39	32%	8%	.21
CHE 311	(18)	(14)		(16)	(16)		(25)	(7)		(19)	(13)	
Avg. Grade	2.39	2.43	.93	2.06	2.75	.09*	2.40	2.43	.96	2.63	2.08	.19
% A's	11%	21%	.63	12%	19%	≅1	20%	0%	.56	21%	8%	.62
CHE 312	(17)	(12)		(14)	(15)		(23)	(6)		(18)	(11)	
Avg. Grade	3.06	2.83	.45	2.86	3.07	.48	2.96	3.00	.91	3.06	2.82	.44
% A's	35%	17%	.41	14%	40%	.22	30%	17%	.65	33%	18%	.63
CHE 446	(15)	(11)		(13)	(13)		(20)	(6)		(18)	(8)	
Avg. Grade	2.87	2.73	.59	2.62	3.00	.12	2.90	2.50	.18	2.94	2.50	.10*
% A's	13%	9%	≅1	0%	23%	.22	16%	0%	.55	17%	0%	.53

†Wilcoxon rank-sum test for average grade, Fisher exact test for percentages

TABLE 5
GRADES IN EXPERIMENTAL CHE COURSES: T/F x MALE/FEMALE

	Thinkers		Feelers	
	Male	**Female**	**Male**	**Female**
AI	(49) 2.77	(17) 3.07	(18) 2.86	(13) 3.02
CHE 205	(58)	(19)	(20)	(15)
Average grade (A=4)	2.43	2.26	2.50	1.93
% A's	28%	26%	30%	7%
CHE 225	(38)	(11)	(14)	(7)
Average grade (A=4)	3.27	3.09	3.00	2.43
% A's	45%	36%	50%	0%
CHE 311	(36)	(10)	(12)	(7)
Average grade (A=4)	2.81	2.70	3.00	2.29
% A's	31%	40%	33%	0%
CHE 312	(35)	(10)	(10)	(6)
Average grade (A=4)	3.31	3.00	3.40	2.83
% A's	51%	30%	50%	0%
CHE 446	(30)	(9)	(9)	(6)
Average grade (A=4)	3.20	3.22	3.11	2.33
% A's	37%	44%	22%	0%

TABLE 6
GRADES IN EXPERIMENTAL CHE COURSES: (S/N x J/P)

STUDENTS WITH AI≥3

	SJ	SP	NJ	NP
CHE 205	(17)	(4)	(11)	(13)
Avg. Grade (A=4)	3.35	2.25	3.09	3.00
% A's	53%	25%	45%	31%
CHE 225	(15)	(3)	(10)	(9)
Avg. Grade	3.67	3.33	3.30	3.00
% A's	67%	33%	60%	33%
CHE 311	(14)	(3)	(10)	(9)
Avg. Grade	3.07	2.33	3.56	2.88
% A's	36%	0%	78%	25%
CHE 312	(13)	(2)	(9)	(8)
Avg. Grade	3.62	4.00	3.44	3.12
% A's	62%	100%	67%	25%
CHE 446	(12)	(2)	(8)	(7)
Avg. Grade	3.33	3.50	3.50	3.14
% A's	42%	50%	62%	43%

STUDENTS WITH AI<3

	SJ	SP	NJ	NP
CHE 205	(34)	(12)	(10)	(15)
Avg. Grade	1.53	1.42	3.00	2.07
% A's	6%	0%	40%	20%
CHE 225	(13)	(4)	(9)	(8)
Avg. Grade	2.92	2.25	3.11	2.50
% A's	23%	0%	44%	12%
CHE 311	(10)	(6)	(9)	(7)
Avg. Grade	2.40	1.50	2.89	2.57
% A's	20%	0%	22%	14%
CHE 312	(10)	(4)	(8)	(7)
Avg. Grade	2.90	2.75	3.25	2.86
% A's	20%	0%	22%	14%
CHE 446	(10)	(3)	(8)	(5)
Avg. Grade	2.70	2.33	3.25	2.60
% A's	0%	0%	38%	0%

TABLE 7
GRADES IN NON-EXPERIMENTAL CHE COURSES

STUDENTS WITH AI≥3

	E	I	p‡	S	N	p‡	T	F	p‡	J	P	p‡
CHE 315	(18)	(24)		(20)	(22)		(27)	(15)		(27)	(15)	
Avg. Grade (A=4)	2.72	3.33	.07*	3.10	3.05	.87	3.33	2.60	.03*	3.30	2.67	.07*
% A's	39%	50%	.54	45%	45%	≅1	56%	27%	.11	56%	27%	.11
CHE 316	(16)	(23)		(19)	(20)		(26)	(13)		(26)	(13)	
Avg. Grade	3.12	3.43	.20	3.05	3.55	.03*	3.31	3.31	≅1	3.38	3.15	.36
% A's	38%	52%	.52	32%	60%	.11	50%	38%	.73	64%	33%	.16
CHE 425	(13)	(19)		(16)	(16)		(22)	(10)		(22)	(10)	
Avg. Grade	3.77	3.63	.48	3.62	3.75	.52	3.68	3.70	.93	3.64	3.80	.43
% A's	77%	68%	.70	62%	81%	.43	73%	70%	≅1	68%	80%	.68
CHE 450	(8)	(14)		(11)	(11)		(15)	(7)		(15)	(7)	
Avg. Grade	2.75	3.14	.32	3.00	3.00	≅1	3.00	3.00	≅1	3.20	2.57	.12
% A's	25%	29%	≅1	36%	18%	.64	27%	29%	≅1	40%	0%	.12

STUDENTS WITH AI<3

	E	I	p‡	S	N	p‡	T	F	p‡	J	P	p‡
CHE 315	(28)	(17)		(24)	(21)		(35)	(10)		(26)	(19)	
Avg. Grade	2.75	2.41	.26	2.58	2.67	.78	2.57	2.80	.51	2.81	2.37	.13
% A's	11%	18%	.66	8%	19%	.40	17%	0%	.31	15%	11%	≅1
CHE 316	(28)	(15)		(20)	(23)		(33)	(10)		(25)	(18)	
Avg. Grade	2.43	2.47	.91	2.35	2.50	.52	2.36	2.70	.36	2.64	2.17	.13
% A's	11%	13%	≅1	4%	20%	.17	12%	10%	≅1	12%	11%	≅1
CHE 425	(19)	(12)		(16)	(15)		(24)	(7)		(19)	(12)	
Avg. Grade	2.79	3.25	.22	2.88	3.07	.61	3.04	2.71	.46	3.11	2.75	.35
% A's	21%	42%	.25	19%	40%	.25	33%	14%	.64	37%	17%	.42
CHE 450	(16)	(9)		(14)	(11)		(20)	(5)		(17)	(8)	
Avg. Grade	2.62	2.00	.05*	2.29	2.55	.41	2.40	2.40	≅1	2.53	2.12	.22
% A's	12%	0%	.52	7%	9%	≅1	10%	0%	≅1	12%	0%	≅1

‡Wilcoxon rank-sum test for average grade, Fisher exact test for percentages

TABLE 8
RETENTION AND GRADUATION IN CHEMICAL ENGINEERING BY TYPE PREFERENCE AND YEAR†

STUDENTS WITH AI≥3

	E (19)	**I** (26)	***p*‡**	**S** (21)	**N** (24)	***p*‡**	**T** (27)	**F** (18)	***p*‡**	**J** (28)	**P** (17)	***p*‡**
Remaining or graduating												
Year 2	95%	96%	≅1	100%	92%	.49	100%	89%	.16	96%	94%	≅1
Year 3	84%	88%	.69	90%	83%	.67	96%	72%	.03*	93%	76%	.18
Year 4	84%	88%	.69	90%	83%	.67	96%	72%	.03*	93%	76%	.18
Year 5	84%	88%	.69	90%	83%	.67	96%	72%	.03*	93%	76%	.18
Graduating												
Year 4	37%	58%	.23	48%	50%	≅1	59%	33%	.13	54%	41%	.54
Year 5	84%	88%	≅1	90%	75%	.25	89%	72%	.24	89%	71%	.23

STUDENTS WITH AI<3

	E (30)	**I** (27)	***p*‡**	**S** (34)	**N** (23)	***p*‡**	**T** (43)	**F** (14)	***p*‡**	**J** (35)	**P** (22)	***p*‡**
Remaining or graduating												
Year 2	97%	78%	.04*	79%	100%	.03*	88%	86%	≅1	83%	95%	.23
Year 3	93%	67%	.02*	74%	91%	.17	79%	86%	.71	77%	86%	.50
Year 4	90%	67%	.05*	71%	91%	.10*	77%	86%	.71	77%	82%	.75
Year 5	83%	52%	.02*	65%	74%	.57	70%	64%	.75	69%	68%	≅1
Graduating												
Year 4	37%	30%	.38	35%	30%	.78	33%	36%	≅1	34%	32%	≅1
Year 5	80%	48%	.02*	62%	70%	.58	67%	57%	.53	66%	64%	≅1

†Percentages of students entering CHE 205 intending to major in chemical engineering who were still chemical engineering majors after the given year. The remainder changed curricula, were suspended, or dropped out of school.

‡Wilcoxon rank-sum test

TABLE 9
RETENTION AND GRADUATION IN CHEMICAL ENGINEERING BY TYPE PREFERENCE AND YEAR: (E/I) x (S/N)†

STUDENTS WITH AI≥3

	ES (7)	**EN** (12	**IS** (14)	**IN** (12)
Remaining or graduating				
Year 2	100%	92%	100%	92%
Year 3	86%	83%	93%	83%
Year 4	86%	83%	93%	83%
Year 5	86%	83%	93%	83%
Graduating				
Year 4	29%	42%	57%	58%
Year 5	86%	83%	93%	67%

STUDENTS WITH AI<3

	ES (18)	**EN** (12	**IS** (16)	**IN** (11)
Remaining or graduating				
Year 2	94%	100%	62%	100%
Year 3	89%	92%	50%	91%
Year 4	89%	92%	50%	91%
Year 5	89%	75%	38%	73%
Graduating				
Year 4	33%	42%	38%	18%
Year 5	83%	75%	38%	64%

†Percentages of students entering CHE 205 intending to major in chemical engineering who were still chemical engineering majors after the given year. The remainder changed curricula, were suspended, or dropped out of school.

TABLE 10
PERCENTAGES GIVING TOP HELPFULNESS RATINGS TO DIFFERENT MODES OF INSTRUCTION[†]

	E	I	p[‡]	S	N	p[‡]	T	F	p[‡]	J	P	p[‡]
Lectures												
CHE 205	4%	9%	.44	5%	9%	.70	6%	9%	.68	11%	0%	.04*
CHE 311	29%	42%	.43	35%	35%	1	37%	32%	.78	45%	18%	.05*
Seniors	31%	52%	.13	50%	32%	.21	40%	44%	.78	47%	30%	.28
In-class groupwork												
CHE 311	16%	3%	.20	10%	10%	1	5%	21%	.07*	8%	14%	.66
Seniors	21%	33%	.41	32%	22%	.41	30%	21%	.55	36%	10%	.04*
Group homework												
CHE 205	43%	33%	.32	31%	48%	.10*	40%	33%	.52	35%	42%	.54
CHE 311	65%	68%	1	61%	71%	59	60%	79%	.24	68%	64%	.78
Seniors	70%	88%	.13	82%	75%	.55	81%	74%	.52	78%	81%	1

[†]In separate questions, the students were asked to rate the helpfulness of lectures, in-class group work (except in CHE 205), and group homework. The ratings were "very helpful" (top rating), "helpful," "average," "not very helpful," and "not at all helpful." The seniors' ratings were collected in the Spring 1993 semester.

[‡]Wilcoxon rank-sum test

TABLE 11
SELF-ASSESSMENTS OF CREATIVE PROBLEM-SOLVING ABILITY

	Spring 1992			Fall 1993			Spring 1993		
Rating	**S**	**N**	**p[†]**	**S**	**N**	**p[†]**	**S**	**N**	**p[†]**
	(29)	(31)		(30)	(31)		(35)	(32)	
Excellent	0%	13%		7%	32%		9%	25%	
Good	34%	48%		47%	58%		60%	56%	
Average	45%	26%	.15	40%	6%	.002*	29%	16%	.14
Fair	14%	10%		3%	3%		3%	0%	
Poor	7%	3%		3%	0%		0%	3%	

[†] Fisher exact test

TABLE 12
PREFERRED CAREER ENVIRONMENT

	S	N	p†
Sophomores	(n=63)	(n=49)	
Large corporation	79%	45%	
Small firm	11%	29%	.001*
University or research facility	8%	24%	
Public service	2%	2%	
Seniors	(n=35)	(n=31)	
Large corporation	69%	48%	
Small firm	20%	16%	.19
University or research facility	9%	23%	
Public service	3%	12%	

† Fisher exact test

TABLE 13
POST-GRADUATION PLANS

Juniors

	E (29)	**I** (31)	*p*†	**S** (29)	**N** (31)	*p*†	**T** (44)	**F** (16)	*p*†	**J** (40)	**P** (20)	*p*†
Grad. School												
– immediately	45%	39%		31%	52%		45%	31%		48%	30%	
– later	17%	29%	.65	28%	19%	.07*	25%	19%	.54	20%	30%	.33
Enter profession	34%	26%		41%	19%		25%	44%		30%	30%	
Take a year off	3%	6%		0%	10%		5%	6%		2%	10%	

Seniors

	E (34)	**I** (33)	*p*†	**S** (35)	**N** (31)	*p*†	**T** (48)	**F** (19)	*p*†	**J** (46)	**P** (21)	*p*†
Grad. School												
– immediately	30%	24%		18%	38%		32%	16%		29%	24%	
– later	18%	18%	.88	21%	16%	.25	21%	11%	.24	16%	24%	.06*
Enter profession	45%	55%		59%	41%		43%	68%		56%	38%	
Take a year off	6%	3%		3%	6%		4%	5%		0%	14%	

† Fisher exact test

TABLE 14
SENIORS' REQUIREMENTS FOR JOB SATISFACTION

	E (30)	I (32)	*p*†	S (31)	N (31)	*p*†	T (46)	F (16)	*p*†	J (41)	P (21)	*p*†
Importance of meeting/exceeding employer expectations												
Very	67%	66%		81%	52%		65%	69%		76%	48%	
Fairly	30%	31%	≅1	19%	42%	.04*	30%	31%	≅1	22%	48%	.07*
Not very/not	3%	3%		0%	6%		4%	0%		2%	5%	
Importance of well defined tasks that don't change frequently												
Very	0%	0%		0%	0%		0%	0%		0%	0%	
Fairly	20%	44%	.11	32%	29%	.79	30%	31%	≅1	34%	24%	.56
Not very/not	80%	60%		67%	71%		70%	69%		66%	76%	
Importance of high salary												
Very	30%	19%		32%	16%		20%	38%		29%	14%	
Fairly	60%	66%	.57	58%	68%	.28	65%	56%	.33	58%	71%	.42
Not very/not	10%	15%		10%	16%		15%	6%		12%	15%	
Importance of variety in job tasks												
Very	50%	31%		48%	32%		39%	44%		42%	38%	
Fairly	43%	59%	.40	45%	58%	.58	52%	50%	.91	51%	52%	≅1
Not very/not	7%	9%		6%	10%		9%	6%		7%	10%	
Importance of good location												
Very	20%	28%		26%	23%		22%	31%		27%	19%	
Fairly	57%	41%	.63	52%	45%	.80	48%	50%	.56	46%	52%	.74
Not very/not	23%	31%		22%	33%		31%	18%		27%	29%	
Importance of doing creative/innovative work												
Very	43%	41%		19%	65%		48%	25%		39%	48%	
Fairly	50%	50%	≅1	65%	35%	.001*	48%	56%	.11	49%	52%	.28
Not very/not	7%	9%		16%	0%		4%	18%		12%	0%	
Importance of job security												
Very	43%	62%		55%	52%		52%	56%		61%	38%	
Fairly	57%	28%	.02*	42%	42%	≅1	41%	44%	.80	37%	52%	.15
Not very/not	0%	9%		3%	6%		6%	0%		2%	10%	
Importance of opportunity for teamwork												
Very	47%	47%		52%	42%		46%	50%		51%	38%	
Fairly	40%	41%	≅1	39%	42%	.78	39%	44%	.84	37%	48%	.66
Not very/not	13%	12%		10%	16%		15%	6%		12%	14%	
Importance of enjoyable work												
Very	90%	97%		97%	90%		96%	88%		98%	86%	
Fairly	10%	3%	.34	3%	10%	.61	4%	12%	.28	2%	14%	.11
Not very/not	0%	0%		0%	0%		0%	0%		0%	0%	
Importance of doing challenging work												
Very	37%	41%		35%	42%		35%	50%		39%	38%	
Fairly	60%	56%	.89	65%	52%	.27	63%	44%	.23	59%	57%	≅1
Not very/not	3%	3%		0%	6%		2%	6%		2%	5%	
Importance of doing socially important/beneficial work												
Very	30%	34%		26%	39%		35%	50%		29%	38%	
Fairly	67%	38%	.01*	55%	48%	.48	63%	44%	.23	51%	52%	.51
Not very/not	3%	28%		19%	13%		2%	6%		20%	10%	
Importance of good relations with coworkers												
Very	87%	84%		97%	74%		85%	88%		88%	81%	
Fairly	13%	16%	≅1	3%	26%	.03*	15%	12%	≅1	12%	19%	.71
Not very/not	0%	0%		0%	0%		0%	0%		0%	0%	

† Fisher exact test